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WINTER NUTRIENT CONTENT AND DEER USE OF GAMBEL OAK TWIGS IN NORTH CENTRAL UTAH

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ABSTRACT.—We examined winter nutritional quality of current-year bud and stem tissues from burned and unburned stands of Gambel oak (*Quercus gambelii* Nutt.). Nutritional analyses were based on the amount of forage consumed by wintering mule deer. Deer use along the Utah Valley foothills averaged 6.25–10.7 cm of current-year growth. Of the tissues examined, post-fire bud tissue had the highest nutrient content, with a mean of 9.51% crude protein, 0.19% phosphorus, and 34.0% in vitro digestibility. Composite values (bud + stem) for unburned stands were slightly higher in crude protein and phosphorus and lower in digestibility than those reported in previous studies. Nutrient values from burned stands were significantly higher than those of unburned stands for all three measures. Tannin content of the burned-area regrowth was also higher. Overall forage value of Gambel oak to wintering mule deer is relatively low.

Key words: Quercus gambelii, Odocoileus hemionus, *nutrients, foraging behavior, utilization, browse, winter.*

Gambel oak (*Quercus gambelii* Nutt.) is a valuable year-round source of food and cover for many wildlife species, including deer, elk, bighorn sheep, small mammals, and a variety of birds (Reynolds et al. 1970, Harper et al. 1985, Tirmenstein 1988). Because of its abundance and location, oak is an important food source for wintering mule deer, providing up to 75% of the available winter browse along the Wasatch Front (Perry 1980). Winter use of oak varies with location, but it has been reported high in some areas along the Wasatch Front, declining in the presence of more palatable rosaceous shrubs (Smith 1952, Julander 1955). Deer use in western North America ranges from moderate to heavy throughout the year (Kufeld et al. 1973 and references therein). In winter preference trials, Smith (1950) and Smith and Hubbard (1954) ranked oak as 7th or higher out of 17 browse species based on time spent browsing and plant weight consumed.

Although important to wintering mule deer in terms of forage availability and palatability, oak ranks among the bottom in nutritional value (Smith 1957, Bunderson et al. 1986). Nutritional studies report winter oak browse as being low in essential nutrients and digestibility (Smith 1957, Kufeld et al. 1981, Meneely and Schemnitz 1981). Smith and Hubbard (1954) described oak as being well liked but of low forage quality. Currently, little information is available on the nutrient content of different portions of the plant stem or on the selection of plant parts by deer.

The effect of fire on the nutritional status of oak browse is also of some interest to land managers. Fire may provide an effective management tool for opening the canopy of the more

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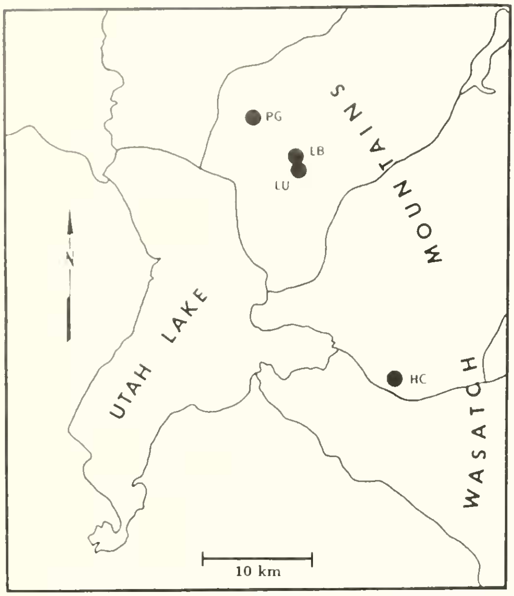

Fig. 1. Location of four oakbrush study sites in Utah County, Utah. PG = Pleasant Grove; LB = Lindon–burned; LU = Lindon–unburned; HC = Hobble Creek Canyon.

dense oak thickets to allow greater herbaceous growth (Anonymous 1966, Dills 1970, Hallisey and Wood 1976, Harper et al. 1985). Deer use of browse species has been found to increase following fire in some (Horn 1938, Hallisey and Wood 1976), but not all (Kufeld 1983), cases. The nutrient content of some oak species has been reported higher following burning (Hallisey and Wood 1976, Meneely and Schemnitz 1981).

The intent of this study was to provide a more accurate assessment of the nutrient content of oak forage consumed by wintering mule deer on the Wasatch Front. Specific objectives were (1) to determine what portion of Gambel oak twigs was used by wintering mule deer in Utah Valley, (2) to determine the percent crude protein, phosphorus, and in vitro digestibility of terminal buds and stems of Gambel oak, and (3) to compare values obtained from adjacent burned and unburned stands.

MATERIALS AND METHODS

Deer utilization was studied at locations near Lindon, Utah, above Pleasant Grove, Utah, and in the mouth of Hobble Creek Canyon (Fig. 1). Vegetation at these foothill locations consists primarily of Gambel oak and sagebrush (*Artemisia tridentata* ssp. *vaseyana*), with scattered patches of cliffrose (*Cowania stansburiana*) and bitterbrush (*Purshia tridentata*). All three locations are heavily used by wintering mule deer. In August 1987 a wildfire burned approximately 1270 acres on the southwest-facing slopes above Orem and Lindon, Utah. Oak present on the burn showed considerable regrowth two months following the fire. Two study sites were established at the Lindon location, one on the burn itself, the other in the adjacent unburned vegetation. Study sites were also established at the Pleasant Grove and Hobble Creek Canyon locations, for a total of four study sites.

Deer utilization was determined by measuring the length of marked twigs before and after browsing. In November of 1987, 679 twigs on the Lindon burn site and 660 twigs on the adjacent unburned site were marked with colored plastic tape. Twigs were selected from around the periphery of multiple clones to represent all directional aspects and a variety of heights accessible to deer. Twig lengths were measured from the tape to the end of the terminal bud. In March 1988 the twigs were remeasured and the number of centimeters browsed determined for each twig. The ratio of bud tissue and twig tissue consumed by deer was then calculated. The procedure was repeated at the Pleasant Grove and Hobble Creek sites the following year, where 186 twigs were marked and measured at each site.

Twenty-two samples for nutritional analysis were collected at mid-winter from 12 burned and 10 unburned oak clones at the Lindon location. Portions of each of the burned clones were fenced in early November to ensure availability of mid-winter collection material. In late January 200–300 stems were removed from each clone, packed in snow, and transported to the laboratory. Twigs were collected from all sides of the periphery of each clone to eliminate possible differences due to directional aspect. At the laboratory, stems from each clone sample were divided into a 1-cm terminal bud portion and an adjacent 10-cm stem. The proportion of current-year growth sampled (11 cm) was approximately equal to that removed by wintering mule deer. Where stem lengths measured less than 11 cm, total current-year growth was used in the analysis. Twig diameters at 1 and 5 cm from the tip were also recorded.

The ensuing 44 bud and stem tissue samples

TABLE 1. Summary of deer utilization on marked twigs of Gambel oak at four study sites in Utah County, Utah.

	No. twigs marked	No. twigs browsed	Percent browsed	Mean utilization (cm)[a]
Lindon–burned	679	194	28.6	10.7 ± 0.44[a]
Lindon–unburned	660	368	55.8	10.7 ± 0.24
Hobble Creek	186	112	60.2	6.3 ± 0.39
Pleasant Grove	186	157	83.9	7.7 ± 0.33

[a]Mean ± standard error

were ground using liquid nitrogen and stored at −80 C. In vitro digestibility, crude protein, and phosphorus were determined for both bud and stem portions. These three measures were considered sufficient to determine overall nutritional quality of oak as they are the nutrients most commonly deficient in winter diets of range animals (Welch et al. 1986). In vitro digestibility was assessed using Pearson's (1970) modification of the Tilley and Terry (1963) technique. This technique, while possibly overestimating in vivo digestion of cell contents in tannin-containing forages (Robbins et al. 1987, Nastis and Malechek 1988), remains the easiest and most accurate of the in vitro techniques (Nastis and Malechek 1988) and is commonly employed in nutritional studies of range forages. Inoculum for the digestion trial was obtained from a slaughter-house steer. The CO_2-injected inoculum was processed within 45 minutes of removal from the rumen (Milchunas and Baker 1982). Studies have shown that inocula obtained from domestic ruminants can successfully approximate digestibility of range forages to deer (Palmer and Cowan 1979, Welch et al. 1983). Phosphorus and crude protein determinations were made at the Plant and Soil Analysis Laboratory at Brigham Young University. Crude protein was based on Kjeldahl nitrogen content. A Technicon Auto Analyzer (Technicon Instrument Corp., Tarrytown, NY) was used to determine phosphorus content. To simplify comparisons with values reported in the literature, composite values for the complete 11-cm sample were calculated as follows: composite value = [10(twig value) + bud value]/11. Bulk samples made up of one twig from each sampled clone were tested for tannin content. Twigs were kept frozen at −80 C until use, then ground under liquid nitrogen. Tannin content for each bulk sample was determined at the Plant and Soil Analysis Laboratory using Hagerman's (1987) radial diffusion method.

Percentage data were arcsine transformed and analyzed using the General Linear Models (GLM) routine available on SAS. The model used was a 2 × 2 factorial design, with burn treatment (burned, unburned) and tissue type (bud, twig) as main effects. Clone was used as the error term for the burn treatment main effect. Tissue differences were also examined separately for burned and unburned areas because of a significant burn treatment × tissue interaction.

RESULTS

Deer use at the Lindon sites averaged 10.7 cm for both burned and unburned clones (Table 1). Individual twig use varied widely, ranging from 1.5 to 33 cm. Although mean use at the two Lindon sites was the same, the burned area had a greater proportion of small bites than the unburned area (Fig. 2). Over 24% of the bites were in the 1.5–5 cm category at the burned site as compared to 5.7% in this category at the unburned site. Also, a smaller percentage of marked twigs was browsed in the burned area (Table 1). Mean use at the Pleasant Grove and Hobble Creek sites during the milder 1988–89 winter was somewhat less than at the Lindon sites, averaging 7.7 and 6.3 cm, respectively (Table 1).

Results from the nutrient analysis of sampled tissues are given in Table 2. Main effects from the analysis of variance were all highly significant. Post-burn sprouts contained more crude protein and phosphorus and were more digestible than unburned samples. Bud tissue exceeded stem tissue in all three measures. The interaction term was also highly significant for crude protein and phosphorus ($p < .0001$ and $p = .0021$, respectively). Running separate analyses for burned and unburned areas revealed that the difference between bud and stem values was greatest for post-burn sprouts, creating the significant interaction term. Bud and

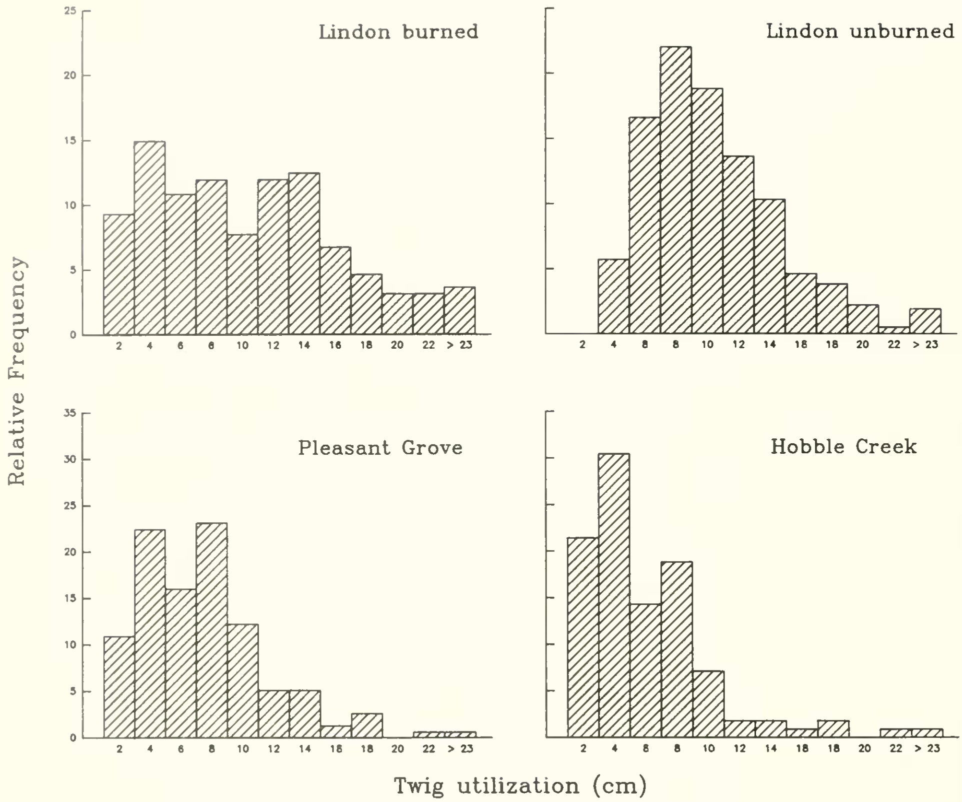

Fig. 2. Distribution of stem utilization at four oakbrush study sites in Utah County, Utah.

TABLE 2. Attained significance values from analyses of variance for nutrient content of Gambel oak.

Source of variation	Crude protein	Phosphorus	Digestibility
Burn treatment	0.0001	0.0002	0.0001
Tissue type	0.0001	0.0001	0.0001
Burn × tissue	0.0001	0.0021	0.3519
Clone	0.0001	0.0228	0.0015

twig values from burned clones differed significantly for all three variables (Table 3). Bud and twig values from unburned clones differed only in nitrogen content. Twigs from burned and unburned clones also differed in appearance, burned twigs being more slender at 1 cm (1.8 mm vs. 2.6 mm; $p = .0002$) and at 5 cm (2.1 mm vs. 2.9 mm; $p = .0001$).

Burning also had a significant effect ($p = .0001$) on tannin content. The bud tissue sample derived from burned clones had a tannin content of 4.1 mg per 100 mg plant tissue compared with 3.4 mg for unburned clones. The stem tissue sample derived from burned clones had a tannin content of 1.6 mg per 100 mg plant tissue compared with 0.7 mg for unburned clones.

DISCUSSION

Previous reports on fall-winter nutrient content of Gambel oak twigs from mature stands range from 4.6% to 5.7% for crude protein, from 0.09% to 0.10% for phosphorus (Smith 1957, Kufeld et al. 1981, Meneely and Schemnitz 1981), and from 26.6% to 40.2% for in vitro digestibility (Kufeld et al. 1981, Meneely and Schemnitz 1981). Similar values have been obtained for other oak species (Meneely and Schemnitz 1981). Composite values from unburned stands in our study (Table 2) are similar to previous results, though slightly higher in crude protein and phosphorus and slightly lower in digestibility. The use of different twig

TABLE 3. Means and standard errors for percent dry matter nutrient content of bud and twig samples collected from burned and unburned oak stands growing near Lindon, Utah. Letters following means indicate significant differences (p = .0001) between bud and twig values within burn treatment. Composite values = [10(twig value) + bud value]/11.

	Crude protein	Phosphorus	Digestibility
Burned stands			
Bud	9.5 ± 0.36 a	0.19 ± 0.0068 a	34.0 ± 0.59 a
Twig	7.5 ± 0.22 b	0.13 ± 0.0092 b	29.8 ± 0.70 b
Composite	7.7 ± 0.23	0.14 ± 0.0087	30.2 ± 0.66
Unburned stands			
Bud	6.5 ± 0.09 a	0.12 ± 0.0056 a	26.2 ± 1.68 a
Twig	5.7 ± 0.10 b	0.11 ± 0.0086 a	23.5 ± 1.15 a
Composite	5.8 ± 0.10	0.11 ± 0.0081	23.7 ± 1.16

lengths for nutrient analysis did not affect the overall results significantly. Composite values based on twig lengths of 7.7 or 6.3 cm (mean deer utilization at Pleasant Grove and Hobble Creek) differed very little from those based on the 11-cm sample. In the absence of foliage, buds provide the highest source of nutrients during late fall and winter. Values for leaves of Gambel oak are substantially higher in summer, but comparable to bud tissue by mid-winter (Urness et al. 1975, Meneely and Schemnitz 1981, Welch et al. 1983, Austin and Urness 1985).

Burning had a significant influence on the nutrient content of oak forage, particularly bud tissue. Values obtained from burned stands were relatively higher than those obtained from unburned stands. Post-burn bud tissue had by far the highest nutritional value of any tissues examined. Increased nutrient content of forage following fire has been reported elsewhere, although indications are that such an increase is temporary (Dills 1970, Hallisey and Wood 1976, Meneely and Schemnitz 1981, DeByle et al. 1989). The evidence to date suggests that improved phosphorus content of forage due to fire is fairly short-lived, usually lasting only one year. Nitrogen benefits may last longer, depending on the species and season. The higher values reported for burned stands in this study likely occurred because sampling took place less than one year following the burn.

Despite the slightly higher values for crude protein and phosphorus reported here for unburned stands and the markedly higher values for recently burned stands, the overall winter nutritional value of Gambel oak remains relatively low. Even post-burn bud tissue, which had the highest nutrient content of any of the tissues sampled, had a crude protein content of less than 10%. The composite value from burned clones was less than 8%, which ranks below that of sagebrush, aspen, and rosaceous shrubs (Smith 1957, Kufeld et al. 1981, DeByle et al. 1989). Actual amounts of protein digested may be somewhat less than predicted by the in vitro technique. Tannins present in summer oak and other forages have been found to increase the fecal excretion of protein by domestic livestock (Robbins et al. 1987). In mule deer and other browsers, nitrogen excretion may be reduced by tannin-binding proteins present in the saliva (Robbins et al 1987). Winter digestibility of Gambel oak is also low when compared to other forages. Bunderson et al. (1986) ranked digestibility of winter oak forage 25th out of 27 species tested. Our results are similar in digestibility to that listed in the ranking, showing slightly higher digestiblity for burned stands and lower digestibility for unburned stands.

Deer use of oak depends on many factors including cover, exposure, density of oakbrush, and availability of other forages (Smith 1952, Julander 1955, Kufeld 1983, Austin and Urness 1985). Fire affects the structure of vegetation and cover as well as quantity and quality of forage produced (Horn 1938, Hallisey and Wood 1976, Meneely and Schemnitz 1981, Kufeld 1983). Whether or not deer use an area more after burning appears to depend on structure of the oak community and type of vegetation present on adjacent areas, as well as intensity and size of burn. Where oak stands form impenetrable thickets, or where little understory is available, burning has resulted in increased use by deer (Horn 1938, Hallisey and Wood 1976). In contrast, Kufeld (1983) found increased use by elk but not deer following burning. Vegetation at this Colorado location consisted of a mixture of mature oak stands, sagebrush, snowberry (*Symphoricarpos albus*), chokecherry (*Prunus virginiana*), and serviceberry (*Amelanchier alnifolia*). Burning eliminated big sagebrush plants and decreased production of several other important browse species, partially as a result of abnormally dry weather conditions.

We found no evidence for increased use on the Lindon burned site (Table 1). The mean number of centimeters browsed at the burned site was identical to that of adjacent unburned stands, even though twigs (sprouts) from the burned stands tended to be longer. Also, a lower percentage of marked twigs was browsed at the burned site. The apparently lower use of burned twigs by deer despite higher nutrient content may be due to several factors. Oak stands in the area form discrete clones rather than large impenetrable thickets. Important browse species such as sagebrush and bitterbrush present on unburned areas were lost as a result of the fire. Also, a lack of cover and increased tannin content of forage on the burn may have had some effect on deer preference.

The oakbrush zone is critical to wintering deer populations along the Wasatch Front. Although not the most preferred winter food, its protective cover and sheer abundance make it one of the most widely used (Smith 1949, Smith and Hubbard 1954, Julander 1955). Current emphasis in the Intermountain region is to manage the oakbrush zone primarily for wildlife (Winward 1985). Several management tools have been suggested, including fire (Harper et al. 1985, Winward 1985). Burning may result in a temporary improvement in nutritional quality, as well as opening the canopy sufficiently to allow establishment of other shrub and forb species. However, without some form of follow-up treatment, the proliferation of oak sprouts may ultimately result in denser, less useable oak forage and reduction of understory species (Harper et al. 1985, Stevens and Davis 1985, Winward 1985). Moreover, the loss of fire-susceptible browse species such as big sagebrush, mountain mahogany, and bitterbrush may have serious consequences for wintering mule deer (Riggs et al. 1990), outweighing any possible benefit.

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